AD-A156 393 USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NON-HYDRAULIC C..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS C C HAMBY ET AL. 1/1

UNCLASSIFIED SEP 84 WES/IR/K-84-10-2 F/G 9/2 NL

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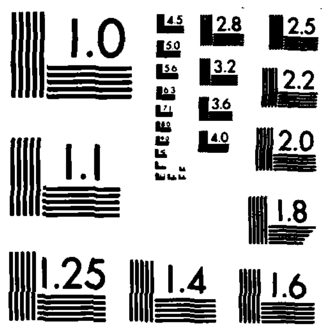

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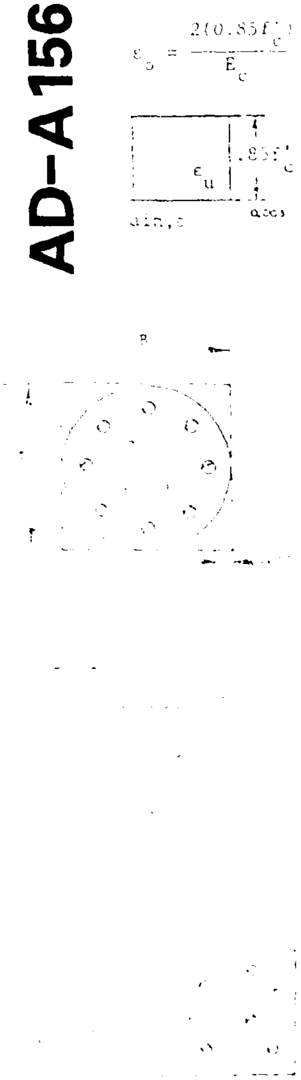
US Army Corps of Engineers

INSTRUCTION REPORT K-84-10

USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS

Report 2

STRENGTH DESIGN OF REINFORCED CONCRETE COLUMN SECTIONS (PCAUC)



by

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Automation Technology Center

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September 1984

Report 2 of a Series

Approved For Public Release; Distribution Unlimited

Prepared for US Army Engineer Division
Lower Mississippi Valley
Vicksburg, Mississippi 39180

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Instruction Report K-84-10

2. GOVT ACCESSION NO.: A150 392

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS; Report 2, STRENGTH DESIGN OF REINFORCED CONCRETE COLUMN SECTIONS (PCAUC)

5. TYPE OF REPORT & PERIOD COVERED: Report 2 of a series

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
Clifton C. Hamby
Deborah K. Martin
William E. Gaylean

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Automation Technology Center
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS:
US Army Engineer Division
Lower Mississippi Valley
Vicksburg, Mississippi 39180

12. REPORT DATE: September 1984

13. NUMBER OF PAGES: 37

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
US Army Engineer Waterways Experiment Station
Automation Technology Center
PO Box 631, Vicksburg, Mississippi 39180-0631

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Columns, concrete--testing--computer programs (LC)
Concrete beams--testing--computer programs (LC)
PCAUC (Computer programs) (LC)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Strength investigation on nonhydraulic beams and columns and strength design of nonhydraulic columns define the program described in this user's guide. The program "Strength Design of Reinforced Concrete Column Sections (PCAUC)" obtained from the Portland Cement Association and adapted to Corps of Engineers usage, applies a fundamental theory and, therefore, is not code-dependent.

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

This program, Portland Cement Association's PCAUC, and another program, Concrete General Strength Investigation (CGSI), complement each other in their capabilities and their equipment requirements.

Program PCAUC may be used to design and/or investigate reinforced concrete compression members. There is no graphics output for results from this program.

Program CGSI investigates the strength of a reinforced concrete member with cross sections subjected to combined axial load and biaxial bending. Results are presented in graphical form.

Neither of the programs considers shear.

Additional keywords: Fortran; Computer files; output.

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM: Strength Design of Reinforced Concrete Column Sections - X0062 (PCAUC)		PROGRAM NO.: 713-F3-H1151
PREPARING AGENCY: US Army Engineer District, Huntington, W. Va.		
AUTHOR(S): Portland Cement Association	DATE PROGRAM COMPLETED: March 1975	STATUS OF PROGRAM — PHASE: / STAGE:

A. PURPOSE OF PROGRAM

Investigation or design of reinforced concrete compression members subjected to axial force and biaxial flexure. Basic use of the program conforms to ACI 318-83 or AASHTO 1980.

The concrete section may be rectangular or circular. Reinforcement may have any pattern for the investigation mode or may be in circular or rectangular symmetrical patterns in the design mode.

B. PROGRAM SPECIFICATIONS

Program is written in FORTRAN IV language.

C. METHODS

In the design mode, the program finds the number and size of bars required to satisfy all loading conditions. In the investigation mode the user has the option of generating interaction data or computing the relationship between applied loading and design strength, holding a constant M_x/M_y ratio.

D. EQUIPMENT DETAILS

Timesharing remote terminal with printer.

E. INPUT-OUTPUT

Input - From a previously saved data file.

Output - Alphanumeric terminal (no graphics).

F. ADDITIONAL REMARKS

User's manual is published by Portland Cement Association.

This user's guide is available from the WES Technical Information Center, Engineer Computer Programs Library (FTS 542-2581).

A version of this program has also been converted to run on the Harris 500.

PREFACE

This user's guide describes a computer program for strength investigation of nonhydraulic beams and columns and strength design of nonhydraulic columns. It is not code-dependent because of the fundamental theory. The program was obtained from the Portland Cement Association and adapted to Corps of Engineers usage.

The work in converting this program and preparing the final user's guide was accomplished with funds provided to the US Army Engineer Waterways Experiment Station (WES) by the Lower Mississippi Valley Division (LMVD) of the Corps of Engineers. This is part of a project to establish a library of available programs for strength design of concrete throughout LMVD.

Program PCAUC (CORPS X0062) was obtained from the Portland Cement Association and adapted to WES time-sharing by Mr. William E. Galyean, formerly with ORHED-DS, now retired. It was enhanced and new documentation was prepared by Mr. Clifton C. Hamby, formerly with the Engineering Applications Group (EAG) of the WES Automation Technology Center (ATC), now with LMKED-DS, and Mrs. Deborah K. Martin, WES.

The work was coordinated by Mr. William A. Price, Chief, EAG, under the direction of Mr. Paul K. Senter, Research Group, Scientific and Engineering Application Group, ATC, and supervision of Dr. N. Radhakrishnan, Chief, ATC. Mr. Victor M. Agostinelli was the point of contact in LMVD.

The Commanders and Directors of WES during the period of this work and publication of this report were COL Tilford C. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees	0.01745329	radians
inches	0.0254	metres
pounds (force) per square inch	6894.757	pascals
square inches	0.00064516	square metres

USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS

STRENGTH DESIGN OF REINFORCED CONCRETE COLUMN SECTIONS (PCAUC)

PART I: INTRODUCTION

General Description of Program

1. Computer program PCAUC will design or investigate the strength of rectangular or circular concrete columns that are symmetrical in shape with reinforcement about both axes. This program will also investigate the strength of beams that are symmetrical in shape but not necessarily symmetrical in reinforcement pattern. PCAUC follows the strength theory for shallow beams and short columns as described in Chapter 10 of ACI Code 318-83. It is written in Fortran IV, requires any time-sharing terminal, and does not consider the effects of shear.

Comparison with Other Strength-Theory Programs

2. This program is one of a pair, both of which follow the same basic theory and ACI Code references. The other program is Concrete General Strength Investigation (CGSI), adapted from the US Bureau of Reclamation's (USBR) program G4BIAXU, written by Mr. Michael D. Davister. This program is described in detail in Report 1 of this series. The two programs, CGSI (X0061) and PCAUC (X0062), complement each other to furnish the capabilities listed below. Both programs will analyze for loadings including axial load with superimposed biaxial flexure, according to Section 10.2 of American Concrete Institute (ACI) Code 318-83. Neither of these programs considers shear. Part II of this report gives full theoretical and input guide information of program PCAUC.

Member-type criteria

3. Beams are defined as having any reinforcing steel pattern, symmetrical or not, with a tensile failure. Program CGSI will analyze unreinforced sections as well. Both programs will investigate beams for percentage of ultimate capacity, along with other information relating to actual strains,

percentage of balanced reinforcement, etc., and can furnish an interaction diagram. They each have simplified input for rectangular and circular cross sections; CGSI also provides for cross sections described by a series of consecutive line segments connecting the corners of an irregular polygon. Neither program will design beams nor investigate shear strengths.

4. Columns are defined as having a reinforcement pattern that is separately symmetrical about both axes and has a compression failure. Both programs provide for the strength of the cross section to be calculated according to ACI 318-83, Section 10.3.5.1 for spiral columns or Section 10.3.5.2 for tied columns, using the same ratio of M_x to M_y as the applied loading. Program CGSI will also investigate columns with unsymmetric reinforcement or no reinforcement. Each program furnishes the percentage of capacity used, interaction diagram values, and actual strains when investigating. PCAUC will design rectangular or circular short columns; CGSI will not. CGSI will, however, investigate columns with any cross section.

Analysis procedure

5. The two programs follow the same strength theory listed in Sections 10.2.2 through 10.2.6 and 10.3 of ACI Code 318-83 for shallow beams and short columns.

6. Program CGSI uses a trapezoidal approximation and program PCAUC uses a parabolic relationship between concrete compressive stress distribution and concrete strain, both in accordance with Section 10.2.6 of ACI 318-83. In analyzing rectangular shapes, CGSI predicts moment strengths.

Force/moment interaction

7. Both programs first compute the theoretical strength of a member on the basis of the strengths of the materials, then reduce the theoretical strength to the design strength by multiplying by the capacity reduction factor as described in Section 9.3 of ACI Code 318-83. The interaction diagram values used to obtain the percentage of design strength of the factored applied load are arrived at by considering a three-dimensional interaction surface. This surface is cut by a P-M plane oriented to the same ratio of M_x to M_y as the applied load. This planar diagram is displayed by program CGSI and optionally printed in tabular form by program PCAUC.

Equipment requirements

8. Equipment requirements are the same in some areas for the two programs but vary in others as listed in the following paragraphs.

a. CGSI (X0061) will run only on a Tektronix 4014 graphics time-sharing terminal. The entire program will run unattended after the data file has been named. Hard copies are made automatically so that nothing is lost.

b. PCAUC (X0062) will run on any terminal. While there are no graphics displays, the printed output can include an optional table of interaction diagram values for the user to plot outside the program.

PART II: DETAILED USER'S GUIDE FOR PROGRAM PCAUC (X0062)

Purpose of Program PCAUC

9. The purpose of this program is to give engineers an easy to use tool for design or investigation of reinforced concrete compression members. The method of solution is based on the strength theory described in ACI Code 318-83 for reinforced concrete. This manual provides background information on the technical aspects of the program and instructions on its use.

General Capabilities and Limitations*

10. Program PCAUC may be used to design or investigate reinforced concrete compression members. The analysis procedure conforms to the ACI 318-83 and 1980 AASHTO codes. (Minimum eccentricity requirements are based on ACI 318-73 procedures.) Research-oriented variations may also be considered by inputing appropriate values for allowable concrete strains and strength reduction factors into the data file.

11. Members and reinforcement patterns may be round or rectangular. In the design mode reinforcement will always be placed in symmetrical patterns, while the investigation mode reinforcement may be placed in any general pattern.

12. Loading conditions may consist of axial loads and uniaxial or biaxial bending. Multiple load cases are permitted, up to a maximum of 70.

13. All results are in alphanumeric form (i.e., no graphics output is available).

Design capabilities

14. Under the design option the program will find the size, number, and distribution of bars that will result in the minimum area of reinforcement with all bars of the same size required to satisfy all the loading conditions imposed on the cross section. For tied members the number of bars in the sides may be different from the top and bottom of the cross section.

15. The user can control the reinforcement pattern to be used and can

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* Major portions of paragraph 10 were extracted from "Strength Design of Reinforced Concrete Column Sections" by Portland Cement Association.

place limits on the number of bars and bar sizes to be considered through the input given in the data file. If no restrictions are specified, the program will investigate the full range of number of bars and bar sizes until the optimum area of steel is found. The program has built-in procedures to eliminate the checking of obviously inadequate bar patterns. These include:

a. Total area of reinforcement outside the reinforcement ratios permitted by the specifications.

b. Bar patterns which result in bar spacings where the clear distance between bars is less than allowed by the specifications.

c. Total area of steel is more than an area which has already been found satisfactory.

However, the amount of computer time required to solve the problem increases proportionally with the number of load cases to be checked, and the range of limits set for the number of bars and bar sizes. The information presented in paragraph 19 on reducing run time should be considered when using the design option.

Investigation capabilities

16. At the option of the user, the program has the capability of generating interaction data or of determining the adequacy of a cross section to resist a given combination of loads. For the latter case the program will hold the eccentricity of the axial load equal to that of the case being investigated. The strength of the cross section for the eccentricity will then be computed, and the relationship between the strength and the applied loading will be reported.

17. Under the investigation option, the program accepts any type of reinforcement configuration, including unsymmetrical patterns. If the engineer desires to compare applied loadings with computed strengths, the input moments must then be given about the geometric centroid. The concrete cross-section outline must be circular or rectangular.

Method of solution

18. The design assumptions for the computation of strength are in accordance with the codes listed in paragraph 9. The method of solution is presented in PCA Advanced Engineering Bulletins 18 and 20.* A brief summary of the method of solutions follows:

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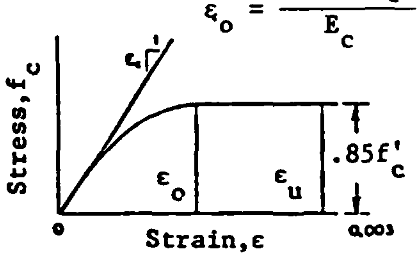
* Advanced Engineering Bulletin 18, "Capacity of Reinforced Rectangular Columns Subject to Biaxial Bending," and Advanced Engineering Bulletin 20, "Biaxial and Uniaxial Capacity Rectangular Columns," published by the Portland Cement Association.

a. Computations of strength are based on the satisfaction of the applicable conditions of equilibrium and compatibility of strains. The stress-strain relationship for concrete is assumed as shown below.

$$E_c = 33w^{1.5}\sqrt{f'_c}$$

$$\varepsilon_o = \frac{2(0.85f'_c)}{E_c}$$



For $0 < \varepsilon \leq \varepsilon_o$

$$f_c = 0.85f'_c\left[2\left(\frac{\varepsilon}{\varepsilon_o}\right) - \left(\frac{\varepsilon}{\varepsilon_o}\right)^2\right] \quad (1)$$

For $\varepsilon_o < \varepsilon < \varepsilon_u$

$$f_c = 0.85f'_c$$

For $\varepsilon < 0$

$$f_c = 0$$

There are provisions in the input to enable the user to change some of the parameters which affect the shape of the compression block. If the value input for EU is less than ε_o , the stress strain curve will consist of a parabola with a maximum height calculated from Equation 1 above.

b. Concrete displaced by reinforcement in compression is deducted from the compression block.

c. Stress in the reinforcement below the design yield strength, f_y , is directly proportional to the strain. For strains greater than that corresponding to the design yield strength, the reinforcement stress remains constant and equal to f_y . The modulus of elasticity, E_s , is taken as 29,000,000 psi,* unless otherwise changed in the input data.

d. Stress in the reinforcement is based on the strain at the actual location of each bar. Reinforcement is defined by the area of each bar and x-y coordinates referred from the centroidal axis of the cross section.

e. All moments are referenced to the centroid of the gross concrete section whether the reinforcement pattern is symmetrical or unsymmetrical.

f. Computations for biaxial loading are based on three-dimensional interaction surface. The method of solution is presented in PCA Advanced Engineering Bulletins 18 and 20.**

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

** Ibid.

g. The program first computes the theoretical strength of a member on the basis of the strengths of the materials, then reduces the theoretical strength to the design strength by the capacity reduction factor. The capacity reduction factor, ϕ , is from ACI 318-77 code.

General notes on design option

19. The engineer can be of great help in increasing the efficiency of the computer operation, by using proper judgment and previous experience. Input data can be prepared to shorten the computer run for solving a given problem. The several means available include:

a. Minimum and maximum ratios of reinforcement can be input in Data Group III-Design Data, if it can be predetermined that the ratio of reinforcement will be within a narrower range than 0.01 to 0.08 used in the program.

b. The minimum acceptable clear spacing of bars can be increased in the input if this is a detailing problem.

c. If the approximate number of bars can be predetermined, or if restrictions can be set for bar sizes, the limits can be input in Data Group IV-Reinforcement Data.

20. When it is determined that a certain bar arrangement is satisfactory, the program proceeds to compute the strength of the cross section under flexure and axial load, and compares this to the applied loadings. Each loading is checked in the same sequence given in the input. The first time that one of the loadings is not satisfied, the checking procedure is terminated and the bar arrangement is rejected. A bar arrangement is accepted only when all the applied loadings are satisfied. In order to speed up the checking procedure, the more critical loading conditions should be input first.

21. The program rejects any cross section when the load strength is less than 0.99 of the applied load. It should be noted that the computed theoretical strength is reduced by the capacity reduction factor ϕ before the comparison is made. For axial loads less than 0.10 $f'_c A_g$, the ϕ factor varies between that for compression members to that for pure flexure, in accordance with ACI 318-77.

22. The engineer may also wish to set standards for acceptance of a cross section. For example, a strength overstress of 5 percent may be accepted instead of the 1 percent programmed. The 5 percent acceptance criteria can be adopted by inputting larger ϕ factors in Data Group IV-Design Data. A factor of 0.735 will result in computed strengths 5 percent larger than those computed for $\phi = 0.70$.

23. The engineer should be aware that this program computes the strength of the cross section based on moments about the geometric centroid of the gross cross section. Therefore, all input moments must also be referenced to the geometric centroidal areas of the concrete section, and all output data should be interpreted likewise. The design capabilities of the program are limited to finding the minimum area of steel for symmetrical reinforcement patterns.

24. It should be noted that any reference axis can be used for design, so long as both the applied moments and resisting moments are referenced to that axis. The geometric centroid is most convenient, since its location is fixed and does not depend on the amount or distribution of the reinforcement. Furthermore, the frame analysis of the structure is usually made by using the geometric centroid of the gross cross section. The moments thus obtained can then be used directly as input into the program. If the engineer has computed applied moments about any other axis, the moments can be easily transferred to the geometric axis by adding a moment equal to the axial load times the distance between the two axes.

Data Input for Program PCAUC

25. PCAUC runs in the timesharing mode. The program is included in the CORPS library and is identified as program X0062.

26. Data for the program may be input interactively or may be input from a previously prepared data file. Each line of data must begin with a line number followed by at least one blank space and the appropriate data values. All data are read free field, that is, each value is separated by a comma and/or one or more blank spaces. All zero values must be included on the line. All data are input according to the following guide.

I. PROBLEM IDENTIFICATION (one line of data)

IDENT

IDENT - Problem identification. The first character after the line number and space must be an asterisk (*) followed by up to 72 characters of project information. Any number of these lines of data may be used.

II. PROBLEM DEFINITION (one line of data)

TYPROB, TYMEM

TYPROB - Defines type of problem. Input D if a design problem or input I if an investigation problem.

TYMEM - Define type of member. Input R for round member, that is, circular cross section with circular reinforcement pattern. Input S for spiral member, that is, rectangular cross section with circular reinforcement pattern. Input T for tied member, that is, rectangular cross section with rectangular reinforcement pattern.

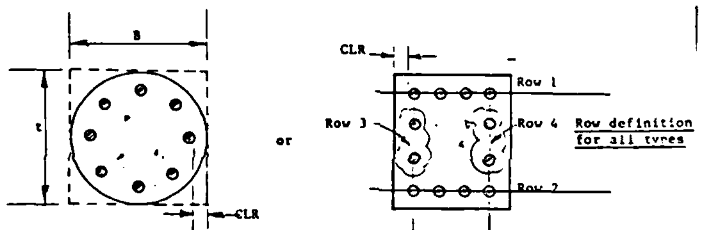
III. DESIGN DATA (one line of data)

B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

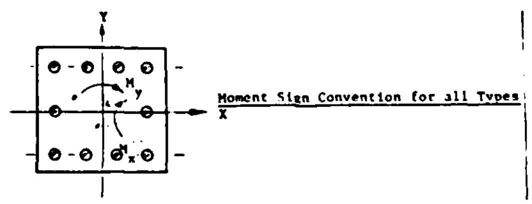
B - Dimension parallel to x-x axis in a rectangular cross section, or diameter of round cross section (in.), see Figure I

T - Dimension parallel to y-y axis in a rectangular cross section, or diameter of round cross section (in.), see Figure I

A. Use paragraph IV-A entitled REINFORCEMENT DATA FOR EQUALLY SPACED BARS if reinforcement is placed in a circular pattern spaced equally around the perimeter of the section or if the same number and size of bars are placed on each side of a rectangular pattern and equally spaced on each side.



B. Use paragraph IV-B entitled REINFORCEMENT DATA FOR UNEQUALLY SPACED BARS if reinforcement is placed in a rectangular pattern with a different number or size of bars in the side rows than in the top row.



C. Use paragraph IV-C entitled REINFORCEMENT DATA FOR RANDOMLY SPACED BARS if reinforcement is placed in a random pattern.

Figure I. Guide for selecting reinforcement data paragraph (Figure from original PCA User's guide)

FPC - Compressive strength of concrete (ksi)

FY - Yield strength of reinforcement (ksi)

PHIC - Capacity reduction factor for compression. If zero, program uses PHIC = 0.75 for round or spiral member and PHIC = 0.70 for tied members.

PHIB - Capacity reduction factor for flexure. If zero, program uses PHIB = 0.90 for all member types.

Note: For a constant value of PHI, PHIB must be equal to PHIC.

ASMIN - Input zero for investigation problem. Input the minimum reinforcement ratio for design. In design, if ASMIN = 0, program sets ASMIN = 0.01.

ASMAX - Input zero for investigation problem. Input the maximum reinforcement ratio for design. In design, if ASMAX = 0, program sets ASMAX = 0.08. Refer to Engineer Technical Letter (ETL) 1110-2-265 for allowable reinforcement ratios.

CLMRN - Input zero for investigation problem. Input the minimum clear spacing for design. In design, if CLRMN = 0, program sets CLRMN = 1.5.

FCM - Concrete stress intensity at the maximum allowable usable strain. If zero, program uses FCM = 0.85 FPC.

EC - Modulus of elasticity for concrete (ksi). If zero, program uses $EC = 145^{1.5}\ 33\sqrt{FPC}$ where 145 is the unit weight of normal concrete.

ES - Modulus of elasticity for reinforcement (ksi). If zero, program uses EMS = 29,000.

EU - Maximum allowable usable strain at the extreme concrete compression fiber (in./in.). If zero, program sets EU = 0.003.

IV. <u>REINFORCEMENT DATA.</u> There are three basic types of reinforcement patterns allowed and the input guide depends on which of these three types is chosen. The diagrams in Figure I identify the types and refer the user to the paragraph which should be used for reinforcement data input.

IV-A. <u>REINFORCEMENT DATA FOR EQUALLY SPACED BARS, SEE FIGURE IA.</u> (One line of data)

This line of data depends on whether the user is designing or investigating a section. Use one of the appropriate lines below:

Design:

RMODE, 0, 0, CLR, NBMIN1, SIZMIN1, CLR1, NBMAX1, SIZMAX1, 0, 0, 0, CLR3, 0, 0, 0

Investigation:

RMODE, NB, SIZBAR, CLR, 0, 0, CLR1, 0, 0, 0, 0, 0, CLR3, 0, 0, 0

RMODE - Reinforcement mode. Input 1 for equally spaced bars

NB - Number of bars in the section

SIZBAR - Size of bars in the section given in standard bar notation

CLR - Clear cover to main reinforcement in inches if cover is the same for all rows. If cover is not the same input zero and define cover later in this line of data

NBMIN1 - Minimum number of bars acceptable to user. For circular steel patterns this is the minimum total number; for rectangular patterns this is the minimum number in row 1

SIZMIN1 - Minimum size bars acceptable to user in standard bar notation

CLR1 - Clear cover in inches for row 1. Clear cover for row 2 will be set to this value also.

NBMAX1 - Maximum number of bars acceptable to user. Defined as in NBMIN paragraph.

SIZMAX1 - Maximum size bar acceptable to user in standard bar notation

CLR3 - Clear cover in inches for row 3. Clear cover for row 4 will be set equal to this value also.

IV-B. <u>REINFORCEMENT DATA FOR UNEQUALLY SPACED BARS, SEE FIGURE IB.</u> (One line of data)

This line of data depends on whether the user is designing or investigating. Use one of the appropriate lines below:

Design:

RMODE, 0, 0, CLR, NBMIN1, SIZMIN1, CLR1, NBMAX1, SIZMAX1, 0, NBMIN3, SIZMIN3, CLR3, NBMAX3, SIZMAX3, 0

Investigation:

RMODE, 0, SIZBAR, CLR, NB1, SIZBAR1, CLR1, NB2, SIZBAR2, CLR2, NB3, SIZBAR3, CLR3, NB4, SIZBAR4, CLR4

RMODE - Reinforcement mode. Input 2 for unequally spaced bars

SIZBAR - Size of bars in standard bar notation in the section if all bars are of the same size. If bars are not the same input zero.

CLR - Clear cover to main reinforcement in inches if cover is the same for all rows. If cover is not the same input zero and define cover later in this line of data.

NBMIN1 - Minimum number of bars acceptable in rows 1 and 2

SIZMIN1 - Minimum size of bars acceptable in rows 1 and 2 in standard bar notation

NBMAX1 - Maximum number of bars acceptable in rows 1 and 2

SIZMAX1 - Maximum bar size acceptable in rows 1 and 2 in standard bar notation

NBMIN3 - Minimum number of bars acceptable in rows 3 and 4

SIZMIN3 - Minimum size of bars acceptable in rows 3 and 4 in standard bar notation

NBMAX3 - Maximum number of bars acceptable in rows 3 and 4

SIZMAX3 - Maximum size of bars acceptable in rows 3 and 4 in standard bar notation

NB1 through NB4 - Number of bars in rows 1 through 4, respectively

SIZBAR1 through SIZBAR4 - Size of bars in rows 1 through 4, respectively

CLR1 through CLR4 - Clear cover in inches for rows 1 through 4, respectively. These data items must have a value even if rows 3 and 4 do not exist in order to locate the corner bars.

IV-C. REINFORCEMENT DATA FOR RANDOMLY SPACED BARS, SEE FIGURE IC. (One line of data followed by as many lines as needed to define reinforcement)

This line of data can only be used for investigation.

Investigation:

RMODE, NB, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 (all on one line)

ABAR1, XBAR1, YBAR1, ABAR2, XBAR2, YBAR2, ABAR3, XBAR3, YBAR3, ABAR4, XBAR4, YBAR4

- repeat this line of data, placing information for four
- bars on each line until all bars are defined. The last
- line must have enough zeros to make 12 items of input

ABARN, XBARN, YBARN, 0, 0, 0, 0, 0, 0, 0, 0, 0

RMODE - Reinforcement mode. Input 3 for randomly placed steel

NB - Total number of bars in section

ABAR1 through ABARN - Area of bars in sq in. for bars 1 through N, respectively

XBAR1 through XBARN - X-coordinate of bars 1 through N, respectively, in inches

YBAR1 through YBARN - Y-coordinate of bars 1 through N, respectively, in inches

V. LOAD MODE DATA, SEE FIGURE I. (One line of data)

This line of data is used to define the manner in which the loadings are given and to request the type of output required. This line of data also depends on whether the user is designing or investigating. Use one of the appropriate lines below.

Design:

3, NLC, MINMOMX, MINMOMY

Investigation:

LMODE, NLC, BENDX, BENDY

LMODE - Loading mode. May be 0, 1, 2, or 3 as described below.

LMODE = 0 If no loadings are given. The user is requesting interaction diagram.

LMODE = 1 If only axial loads are given. The user is requesting interaction diagram.

LMODE = 2 If axial loads are given as groups of loads, i.e., each group consists of an initial value of P, a final value, and an increment. The user is requesting interaction diagram.

LMODE = 3 If axial loads and uniaxial or biaxial bending is given. The user is requesting a comparison between the applied loadings and the strength of the cross section.

NLC - Number of load cases to follow. One line of data per load case

MINMOMX - Minimum moment applied about the X-axis. Input must be 1 or zero. An input of 1 will cause a minimum moment to be applied in accordance with the ACI Code 318-73 to account for minimum eccentricities. If loadings consist only of axial loads, then a 1 should be input. If the loading case contains a moment this input item will be ignored.

MINMOMY - Minimum moment applied about the Y-axis. Input must be 1 or zero as discussed in MINMOMX above.

BENDX - Bending applied about the X-axis. Input must be 1 or zero. An input of one means that an interaction diagram is requested about the X-axis and that any MX moments given in the load cases are to be applied.

BENDY - Bending applied about the Y-axis. Input must be 1 or zero as described in BENDX above. Note that to consider biaxial bending both BENDX and BENDY must equal 1.

VI. <u>LOAD DATA.</u> There are three types of data depending on the user's selected value of LMODE.

VI-A. <u>LOAD DATA FOR LMODE = 1.</u> (One line of data per load)

1, AP

AP - Axial load with load factors in kips. Up to 70 loads may be specified. (Must be +)

VI-B. <u>LOAD DATA FOR LMODE = 2.</u> (One line of data per load group)

1, APINIT, APFINAL, APINCRE

APINIT - Initial value of axial load in kips. (Must be +)

APFINAL - Final value of axial load in kips. (Must be +)

APINCRE - Increment of axial loading between APINIT and APFINAL to be applied; i.e., a range of axial loads can be applied between APINIT and APFINAL each load differing in value from the preceding load by APINCRE. Up to 70 loadings can be applied.

VI-C. <u>LOAD DATA FOR LMODE = 3.</u> (One line of data per load set)

1, AP, AMX, AMY

AP - Applied axial load with load factors, in kips. (Must be +)

AMX - Applied moment in kip-feet about the X-axis, with load factors. (Must be +)

AMY - Applied moment in kip-feet about the Y-axis, with load factors. A maximum of 70 loading sets may be applied. (Must be +)

Note: For a design problem, it is possible to specify a loading condition consisting of an axial load and the minimum design eccentricity. To do this, MINMOMX and MINMOMY must be input as 1. Then a value of AP must be input and MX and MY must be zero. The program will then supply minimum design moments as follows:

If MINMOMX = 1 (bending about x-axis),

MX = 0.05 (T/12) P or P/12, whichever is greater for round and spiral members

= 0.10 (T/12) P or P/12, whichever is greater for tied members

If MINMOMY = 1 (bending about y-axis),

MY = 0.05 (B/12) P or P/12, whichever is greater for round and spiral members

= 0.10 (B/12) P or P/12, whichever is greater for tied members

If MINMOMX = 1 and MINMOMY = 1 the above moments will be applied simultaneously as biaxial bending.

If MINMOMX = 1 and MINMOMY = 1 the above moments will be applied simultaneously as biaxial bending.

VII. RUN INDICATOR DATA

IA

IA - Input 1 to process another set of data
0 if no more data are to be read

Summary data files

27. Sample data files are listed below to illustrate how the various options are implemented.

a. Design of equally spaced bar pattern

900 IDENT

1000 TYPROB, TYMEM

1010 B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

1020 RMODE, O, O, CLR, NBMIN1, SIZMIN1, CLR1, NBMAX1, SIZMAX1, O, O, O, CLR3, O, O, O

1030 3, NLC, MINMOMX, MINMOMY

1040 1, AP, AMX, AMY (LMODE = 3 Option shown here)

1050 IA

b. Design of unequally spaced spaced bar pattern

900 IDENT

1000 TYPROB, TYMEM

1010 B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

1020 RMODE, O, O, CLR, NBMIN1 SIZMIN1, CLR1, NBMAX1, SIZMAX1, O, NBMIN3, SIZMIN3, CLR3, NBMAX3, SIZMAX3, O

1030 3, NLC, MINMOMX, MINMOMY

1040 1, AP, AMX, AMY (LMODE = 3 Option shown here)

1050 IA

c. Investigation of equally spaced bar pattern

900 IDENT

1000 TYPROB, TYMEM

1010 B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

1020 RMODE, NB, SIZBAR, CLR, O, O, CLR1, O, O, O, O, O, CLR3, O, O, O

1030 3, NLC, MINMOMX, MINMOMY

1040 1, AP, AMX, AMY (LMODE = 3 Option shown here)

1050 IA

d. Investigation of unequally spaced bar pattern

900 IDENT

1000 TYPROB, TYMEM

1010 B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

1020 RMODE, 0, SIZBAR, CLR, NB1, SIZBAR1, CLR1, NB2, SIZBAR2, CLR2, NB3, SIZBAR3, CLR3, NB4, SIZBAR4, CLR4

1030 3, NLC, MINMOMX, MINMOMY

1040 1, AP, AMX, AMY (LMODE = 3 Option shown here)

1050 IA

e. Investigation of randomly spaced bar pattern

900 IDENT

1000 TYPROB, TYMEM

1010 B, T, FPC, FY, PHIC, PHIB, ASMIN, ASMAX, CLRMN, FCM, EC, ES, EU

1020 RMODE, NB, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

1030 ABAR1, XBAR1, YBAR1, ABAR2, XBAR2, YBAR2, ABAR3, XBAR3, YBAR3, ABAR4, XBAR4, YBAR4

.
.
.

1040 ABARN, XBARN, YBARN, 0, 0, 0, 0, 0, 0, 0, 0, 0

1050 3, NLC, MINMOMX, MINMOMY

1060 1, AP, AMX, AMY (LMODE = 3 Option shown here)

1070 IA

Description of Output

28. Output listings are, for the most part, self-explanatory. After the program identification, the information on the header data lines is printed out, followed by the problem type option and the type of member.

29. The next line of output contains:

FC - Concrete stress intensity (0.85 f'_c)

EC - Modulus of elasticity for concrete

ES - Modulus of elasticity for reinforcement

STRAIN - Maximum usable allowable strain at the extreme compression fiber

Pertinent dimension data is given on the next line. This includes:

B - Dimension parallel to x-x axis or the diameter

T - Dimension parallel to y-y axis or the diameter

F'C - Compressive strength of concrete

FY - Yield strength of reinforcement

PHIC - Capacity reduction factor for compression

PHIB - Capacity reduction factor for flexure

30. If the option is investigation, the given reinforcement will be printed next. If the option is design, the data for the selected reinforcement will be printed after the design is completed. If no suitable reinforcement pattern was found, a message stating this will be printed.

31. The output that follows the reinforcement data will depend on whether the problem is design or investigation and the type of loading. All axial loads are specified in kips and moments in kip-ft.

Design option output*

32. For each loading condition, the following data will be printed:

(1) Loading Case Number

(2) The applied loadings as given in the input

AP = Applied axial load

AMX = Applied moment component in the direction of the x-axis

AMY = Applied moment component in the direction of the y-axis

(3) The computed strength under combined flexure and axial load for the selected reinforcement assuming that the eccentricity of the axial load remains constant

UP = P_u = axial load strength

UMX = M_x = moment strength component in the direction of the x-axis

UMY = M_y = moment strength component in the direction of the x-axis

UMY = M_y = moment strength component in the direction of the y-axis

(4) The ratio of the axial load strength to the applied axial load (UP/AP). This ratio will always be larger than 0.990.

Investigation option output

33. LMODE = 0. The control points of the interaction diagram will be printed for each of the axes requested in the input. Control points are identified as follows:

---

* Extracted from "Strength Design of Reinforced Concrete Column Sections" by Portland Cement Association.

PZ = P_o = axial load strength of section in pure compression

PB = P_b = axial load strength of section at simultaneous assumed ultimate strain of concrete and yielding of tension reinforcement (balanced conditions)

MB = M_b = moment strength of section at simultaneous assumed ultimate strain of concrete and yielding of tension reinforcement (balanced conditions)

MZ = M_o = moment strength in pure flexure (P_u = 0)

34. LMODE = 1 or 2. Moment strengths will be printed for each axial load listed in the input (combined bending and axial load strengths). If uniaxial interaction data were requested in the input, only the moment strength about the specified axis will be printed.

35. If biaxial interaction data were requested in the input, the following information will be printed for each axial load:

a. Loading Case Number

b. UP = P_u = axial load strength

UMX = M_{ux} = moment strength in the direction of the x-axis with bending considered about the x-axis only

UMY = M_{uy} = moment strength in the direction of the y-axis with bending considered about the y-axis only

DXM = M_x = moment strength component in the direction of the x-axis when the neutral axis is parallel to the diagonal axis through the corners of a rectangular cross section or a 45 deg axis for circular cross sections

DYM = M_y = moment strength component corresponding to DXM above

DRM = the resultant of the DXM and DYM moments defined above. For a circular or a square cross section DRM is the moment strength for biaxial bending about the diagonal axis

BETA = B = a coefficient which defines the interaction contour for the biaxial moment relationship (see reference cited under Item (f), paragraph 18 Method of Solution).

EXP = n = exponent used in the biaxial bending design formula:

$$\left(\frac{M_x}{M_{ux}}\right)^n + \left(\frac{M_y}{M_{uy}}\right)^n = 1$$

For the use of this formula refer to the references cited under paragraph 18 Method of Solution.

36. LMODE = 3. Under this mode, the output will be a comparison between the applied loadings given in the input and the computed strength of the cross section under combined flexure and axial load. The form of the output will be identical to that printed for the design option output. The adequacy of the section investigated to resist the applied loadings can be readily determined from the ratio of UP/AP printed in the last column of the listing. Limiting axial load strengths are printed to show the maximum axial loads permitted for zero moments.

Sample Problems

37. Six sample problems follow. Problem 1 is the design of a 36-in.-round column for five applied loading conditions. Problem 2 is an investigation of a 24- by 42-in. cross section for load versus moment interaction data. Problem 3 is the same as problem 1 except FCM, EC, EMS, and EU are specified in the input data instead of using default values. Problems 4 and 2 are the same except the irregular reinforcement pattern option is used. Problem 5 is an interactive input for design of a 36-in.-round column. Problem 6 is an interactive input for investigation of a 36-in.-round column.

Example data

38. Sample problems 1 through 4 show examples for each problem.

```
◆SAMPLE PROBLEM NO. 1 - DESIGN OF 36 IN ROUND COLUMN
D R
36. 36.  5. 60. 0.75 0.90 0.    0.    0.  0.          0.         0.  0.
1   0   0   2.00 23  8    0.    25 10    0.     0  0    0.     0  0    0.
 3  5  1  0
1    90.0 1240.0      0.
1   540.0 1500.0      0.
1   990.0 1640.0      0.
1 1580.0 1600.0       0.
1 2040.0 1480.0       0.
 1
◆SAMPLE PROBLEM NO. 2 - INVESTIGATION OF 24 X 24 TIED MEMBER
◆REQUESTING INTERACTION DIAGRAM
◆PHI = 1.0 FOR THEORETICAL STRENGTH
I T
24. 42.  5. 60. 1.00 1.00 0.    0.    0.  0.          0.         0.  0.
 2   0   0    2.00  6 10    0.    .6 10    0.     8  8    0.     8  8    0.
 2   1   1   0
1     0.  5800.0  200.0
 1
◆SAMPLE PROBLEM NO. 3 - SAME AS SAMPLE PROBLEM NO. 1
◆USING OPTIONAL INPUT VARIABLES
D R
36. 36.  5. 60. 0.75 0.90 0.    0.    0.  4.25  4074.0 29000.0 0.003
1   0   0    2.00 23  8    0.    25 10    0.     0  0    0.     0  0    0.
 3   5   1   0
1    90.0 1240.0      0.
1   540.0 1500.0      0.
1   990.0 1640.0      0.
1 1580.0 1600.0       0.
1 2040.0 1480.0       0.
 1
◆SAMPLE PROBLEM NO. 4 - SAME AS SAMPLE PROBLEM NO. 2
◆USING IRREGULAR REINFORCEMENT PATTERN OPTION
I T
24. 42.  5. 60. 1.00 1.00 0.    0.    0.  4.25  4074.0 29000.0 0.003
3 28   0    0.    0  0    0.     0  0    0.     0  0    0.     0  0    0.
     1.270     3.750    18.375     1.270     7.500    18.375
     1.270    11.250    18.375     1.270    -3.750    18.375
     1.270    -7.500    18.375     1.270   -11.250    18.375
     1.270     3.750   -18.375     1.270     7.500   -18.375
     1.270    11.250   -18.375     1.270    -3.750   -18.375
     1.270    -7.500   -18.375     1.270   -11.500   -18.375
     0.790   -11.250    14.292     0.790    11.250    14.292
     0.790   -11.250    10.209     0.790    11.250    10.209
     0.790   -11.250     6.126     0.790    11.250     6.126
     0.790   -11.250     2.043     0.790    11.250     2.043
     0.790   -11.250    -2.043     0.790    11.250    -2.043
     0.790   -11.250    -6.126     0.790    11.250    -6.126
     0.790   -11.250   -10.209     0.790    11.250   -10.209
     0.790   -11.250   -14.292     0.790    11.250   -14.292
  2   1   1   0
1     0.  5800.0  200.0
 0
```

Example output

39. Examples of printout follow for sample problems 1 through 4.

```
*FFN WESLIB/CORPS/X0062,R
****************************
* CORPS PROGRAM #  X0062   *
*       VERSION # 83/10/01 *
****************************

INPUT NAME OF DATA FILE.  HIT A CARRIAGE
RETURN IF DATA IS TO COME FROM TERMINAL.

=PCADAT

INPUT NAME OF OUTPUT FILE.  HIT A CARRIAGE
RETURN IF OUTPUT IS TO BE WRITTEN TO TERMINAL

=
```

```
                    STRENGTH DESIGN OF R/F.
                 CONCRETE COMPRESSION MEMBER      -PCA-
     ************************************************************

SAMPLE PROBLEM NO. 1 - DESIGN OF 36 IN ROUND COLUMN

DESIGN OF
ROUND COMPRESSION MEMBERS

     CONSTANTS -  FC= 4.250  EC=  4074.   ES= 29000.   STRAIN= 0.0030

S= 36.00  T= 36.00  F'C= 5.000  FY= 60.000  PHIC= 0.750  PHIB= 0.900

USE- 24 NO. 9 BARS.   AST = 24.00 SQ.IN. =  2.36 PCT.  COVER = 2.000 IN.

 LOAD       APPLIED  LOADS          COMPUTED  STRENGTH
 CASE      AP      AMX      AMY       UP     UMX      UMY        UP/AP
   1       90.    1240.      0.      104.   1443.      0.        1.164
   2      540.    1500.      0.      544.   1506.      0.        1.004
   3      990.    1640.      0.      997.   1648.      0.        1.005
   4     1580.    1600.      0.     1591.   1610.      0.        1.006
   5     2040.    1480.      0.     2048.   1488.      0.        1.004

LIMITING AXIAL LOAD   -  UP(MAX)=   3611.
```

STRENGTH DESIGN OF R/F.
CONCRETE COMPRESSION MEMBER --CA-

SAMPLE PROBLEM NO. 2 - INVESTIGATION OF 24 X 24 TIED MEMBER
REQUESTING INTERACTION DIAGRAM
PHI = 1.0 FOR THEORETICAL STRENGTH

INVESTIGATION OF
TIED COMPRESSION MEMBERS

CONSTANTS - FC= 4.250 EC= 4074. ES= 29000. STRAIN= 0.0030

B= 24.00 T= 42.00 F'C= 5.000 FY= 60.000 PHIC= 1.000 PHIB= 1.000

WITH 28 NO. 8 BARS. AST = 27.88 SQ.IN. = 2.77 PCT. COVER = 2.000 IN.

	ROW 1	ROW 2	ROW 3	ROW 4
BARS	6 NO.10	6 NO.10	8 NO. 8	8 NO. 8
COVER	2.000	2.000	2.000	2.000

UNIAXIAL INTERACTION REQUESTED

LOAD	UP	UMX
1	0.	2454.
2	200.	2667.
3	400.	2855.
4	600.	3012.
5	800.	3145.
6	1000.	3258.
7	1200.	3341.
8	1400.	3401.
9	1600.	3439.
10	1800.	3446.
11	2000.	3389.
12	2200.	3295.
13	2400.	3198.
14	2600.	3097.
15	2800.	2989.
16	3000.	2873.
17	3200.	2748.
18	3400.	2612.
19	3600.	2460.
20	3800.	2293.
21	4000.	2110.
22	4200.	1912.
23	4400.	1699.
24	4600.	1485.
25	4800.	1267.
26	5000.	1043.
27	5200.	815.
28	5400.	580.
29	5600.	332.
30	5800.	58.

LIMITING AXIAL LOADS - UP(MAX)= 4671.

SAMPLE PROBLEM NO. 3 - SAME AS SAMPLE PROBLEM NO. 1
USING OPTIONAL INPUT VARIABLES

DESIGN OF
ROUND COMPRESSION MEMBERS

CONSTANTS - FC= 4.250 EC= 4074. ES= 29000. STRAIN= 0.0030

B= 36.00 T= 36.00 F'C= 5.000 FY= 60.000 PHIC= 0.750 PHIB= 0.900

USE- 24 NO. 9 BARS. AST = 24.00 SQ.IN. = 2.36 PCT. COVER = 2.000 IN.

LOAD	APPLIED LOADS			COMPUTED STRENGTH			
CASE	AP	AMX	AMY	UP	UMX	UMY	UP/AP
1	90.	1240.	0.	104.	1443.	0.	1.164
2	540.	1500.	0.	544.	1506.	0.	1.004
3	990.	1640.	0.	997.	1648.	0.	1.005
4	1580.	1600.	0.	1591.	1610.	0.	1.006
5	2040.	1480.	0.	2048.	1488.	0.	1.004

LIMITING AXIAL LOADS - UP(MAX)= 3611.

STRENGTH DESIGN OF R/F.
CONCRETE COMPRESSION MEMBER -PCA-

SAMPLE PROBLEM NO. 4 - SAME AS SAMPLE PROBLEM NO. 2
USING IRREGULAR REINFORCEMENT PATTERN OPTION

INVESTIGATION OF
TIED COMPRESSION MEMBERS

CONSTANTS - FC= 4.250 EC= 4074. ES= 29000. STRAIN= 0.0030

B= 24.00 T= 42.00 F'C= 5.000 FY= 60.000 PHIC= 1.000 PHIB= 1.000

WITH 28 NO. 0 BARS. AST = 27.88 SQ.IN. = 2.77 PCT. COVER = 0. IN.
BAR AREAS AND X,Y COORDINATES AS GIVEN

UNIAXIAL INTERACTION REQUESTED

LOAD	UP	UMX
1	0.	2455.
2	200.	2668.
3	400.	2856.
4	600.	3013.
5	800.	3146.
6	1000.	3260.
7	1200.	3342.
8	1400.	3402.
9	1600.	3440.
10	1800.	3447.
11	2000.	3390.
12	2200.	3296.
13	2400.	3199.
14	2600.	3098.
15	2800.	2990.
16	3000.	2874.
17	3200.	2749.
18	3400.	2612.
19	3600.	2461.
20	3800.	2294.
21	4000.	2111.
22	4200.	1912.
23	4400.	1700.
24	4600.	1466.

25	4800.	1267.
26	5000.	1044.
27	5200.	815.
28	5400.	580.
29	5600.	332.
30	5800.	58.

LIMITING AXIAL LOADS - UP(MAX)= 4671.

** END OF RUNS **

Example interactive runs

40. The following examples, 5 and 6, show the actual computer runs.

(Example 5)

```
*FRN WESLIB/CORPS/X0062,R

****************************
* CORPS PROGRAM #  X0062   *
*       VERSION # 83/10/01 *
****************************

INPUT NAME OF DATA FILE.  HIT A CARRIAGE
RETURN IF DATA IS TO COME FROM TERMINAL.

=

INPUT NAME OF FILE DATA IS TO BE WRITTEN TO
HIT A CARRIAGE RETURN IF YOU DO NOT WANT TO SAVE
THIS FILE.

=DATCOL

FILE ALREADY EXISTS.

INPUT NAME OF FILE DATA IS TO BE WRITTEN TO
HIT A CARRIAGE RETURN IF YOU DO NOT WANT TO SAVE
THIS FILE.

=DATCOL2

INPUT A ? IF MORE INFORMATION IS NEEDED ABOUT DATA BEING REQUESTED

INPUT PROBLEM IDENTIFICATION - IDENT
=?

IDENT - AN * FOLLOWED BY UP TO 65 CHARACTERS OF PROJECT INFORMATION
=* EXAMPLE

INPUT PROBLEM IDENTIFICATION - IDENT. HIT A CARRIAGE
 RETURN IF NO MORE IDENTIFICATION
=

INPUT PROBLEM DEFINITION - TYPROB,TYMEM
=?

TYPROB = D IF DESIGN PROBLEM OR I IF INVESTIGATION
TYMEM = R FOR ROUND MEMBER
        S FOR SPIRAL MEMBER
        T FOR TIED MEMBER
=D R
```

```
INPUT DESIGN DATA - B,T,FPC,FY,PHIC,PHIB,ASMIN,
    ASMAX,CLRMN,FCM,EC,EMS,EU
=?

B - DIMENSION PARALLEL TO X-X AXIS IN RECTANGULAR CROSS SECTION
    DIAMETER OF ROUND CROSS SECTION
T - DIMENISION PARRALLEL TO Y-Y AXIS
    DIAMETER
FPC - COMPRESSIVE STRENGTH OF CONCRETE
FY - YIELD STRENGTH OF REINFORECEMENT
PHIC - CAPACITY REDUCTION FACTOR FOR COMPRESSION
       IF ZERO, PROGRAM SETS PHIC TO 0.75
PHIB - CAPACITY REDUCTION FACTOR FOR FLEXURE
       IF ZERO,PROGRAM SETS PHIB TO 0.70
ASMIN - INPUT 0 FOR INVESTIGATION PROBLEM
        MINIMUM REINFORCEMENT RATIO FOR DESIGN
        IF ZERO IN DESIGN ASMIN IS SET TO 0.01
ASMAX - INPUT 0 FOR INVESTIGATION
        MAXIMUM REINFORCEMENT RATIO FOR DESIGN
        IF ZERO IN DESIGN IT IS SET TO 0.08
CLRMN - INPUT ZERO FOR INVESTIGATION
        MINIMUM CLEAR SPACING FOR DESIGN
        IF ZERO IN DESIGN IT IS SET TO 1.5
FCM - CONCRETE STRESS INTENSITY AT MAXIMUM ALLOWABLE USABLE STRAIN
      IF 0 PROGRAM USES 0.85FPC
EC - MODULUS OF ELASTICITY FOR CONCRETE
EMS - MODULUS OF ELASTICITY FOR REINFORCEMENT
EU - MAXIMUM ALLOWABLE USABLE STRAIN AT EXTREME COMPRESSION FIBER
=36.0 36.0 5.0 60.0 .75 .90 0 0 0 0 0 0 .003
```

```
INPUT TYPE OF REINFORCEMENT - RMODE
=?

RMODE = 1 FOR EQUALLY SPACED BARS
        2 FOR UNEQUALLY SPACED BARS
        3 FOR RANDOMLY SPACED BARS
=1

REINFORCEMENT DATA - 0,0,CLR,NBMIN1,SIZMIN1,CLR1,NBMAX1,SIZMAX1
                     0,0,0,CLR3,0,0,0
=?

CLR - CLEAR COVER TO MAIN REINFORCEMENT(IN)
       IF SAME FOR ALL ROWS
      IF COVER IS NOT SAME, INPUT ZERO
NBMIN1 - MINIMUM NUMBER OF BARS
         FOR CIRCULAR PATTERNS, MINIMUM TOTAL NUMBER
         FOR RECTANGULAR PATTERNS, MINIMUM NUMBER IN ROW 1
SIZMIN1 - MINIMUM SIZE OF BARS
CLR1 - CLEAR COVER FOR ROW 1 (IN)
NBMAX1 - MAXIMUM NUMBER OF BARS
SIZMAX1 - MAXIMUM SIZE OF BARS
CLR3 - CLEAR COVER FOR ROW 3 (IN)
=0 0 2.0 23 8 0 25 10 0 0 0 0 0 0 0
```

```
INPUT LOAD MODE DATA - NLC,MINMOMX,MINMOMY
=?

NLC - NUMBER OF LOAD CASES
MINMOMX - MOMENT ABOUT X-AXIS
        = 1 FOR A MINIMUM MOMENT TO BE APPLIED IN
            ACCORDANCE WITH ACI 318-73 CODE
          0 EACH LOAD CASE HAS A MOMENT
MINMOMY - MOMENT ABOUT Y-AXIS. MUST BE 1 OR 0
=5 1 0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=?

AP - APPLIED AXIAL LOAD WITH LOAD FACTORS (KIPS)
AMX - APPLIED MOMENT COMPONENT IN X-DIRECTION (KIP-FT)
AMY - APPLIED MOMENT COMPONENT IN Y-DIRECTION (KIP-FT)
=1 45.0 620.0 0.0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=1 270.0 750.0 0.0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=1 490.0 820.0 0.0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=1 800.0 800.0 0.0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=1 1040.0 780.0 0.0

LOAD DATA - 1,AP,AMX,AMY
HIT CARRIAGE RETURN IF NO MORE DATA
=

RUN INDICATOR - IA
=?

IA = 1 TO PROCESS ANOTHER SET OF DATA
     0 IF NO MORE DATA IS TO BE READ
=0
```

```
INPUT NAME OF OUTPUT FILE.  HIT A CARRIAGE
RETURN IF OUTPUT IS TO BE WRITTEN TO TERMINAL

=
```

```
                    STRENGTH DESIGN OF R/F.
                 CONCRETE COMPRESSION MEMBER      -PCA-
 ************************************************************

 EXAMPLE

DESIGN OF
ROUND COMPRESSION MEMBERS

     CONSTANTS -  FC= 4.250  EC=  4074.   ES= 29000.   STRAIN= 0.0030

B= 36.00  T= 36.00  F'C= 5.000  FY= 60.000  PHIC= 0.750  PHIB= 0.900

USE- 23 NO. 8 BARS.  AST = 18.17 SQ.IN. =  1.79 PCT.  COVER = 2.000 IN.

 LOAD       APPLIED  LOADS          COMPUTED  STRENGTH
 CASE       AP      AMX      AMY        UP     UMX      UMY       UP/AP
   1        45.     620.      0.        83.   1152.      0.       1.859
   2       270.     750.      0.       457.   1274.      0.       1.698
   3       490.     820.      0.       854.   1426.      0.       1.740
   4       800.     800.      0.      1469.   1470.      0.       1.836
   5      1040.     780.      0.      1861.   1391.      0.       1.787

 LIMITING AXIAL LOADS    -  UP(MAX)=    3404.


    ** END OF RUNS **
```

(Example 6)

```
*FRN WESLIB/CORPS.X0062*R
*****************************
* CORPS PROGRAM #   X0062   *
*       VERSION # 83/10/01  *
*****************************

INPUT NAME OF DATA FILE.  HIT A CARRIAGE
RETURN IF DATA IS TO COME FROM TERMINAL.

=

INPUT NAME OF FILE DATA IS TO BE WRITTEN TO
HIT A CARRIAGE RETURN IF YOU DO NOT WANT TO SAVE
THIS FILE.

=DATCOL1

INPUT A ? IF MORE INFORMATION IS NEEDED ABOUT DATA BEING REQUESTED

INPUT PROBLEM IDENTIFICATION - IDENT
=?

IDENT - AN * FOLLOWED BY UP TO 65 CHARACTERS OF PROJECT INFORMATION
=* EXAMPLE

INPUT PROBLEM IDENTIFICATION - IDENT. HIT A CARRIAGE
 RETURN IF NO MORE IDENTIFICATION
=

INPUT PROBLEM DEFINITION - TYPROB,TYMEM
=?

TYPROB = D IF DESIGN PROBLEM OR I IF INVESTIGATION
TYMEM = R FOR ROUND MEMBER
        S FOR SPIRAL MEMBER
        T FOR TIED MEMBER
=I R
```

```
INPUT DESIGN DATA - B,T,FPC,FY,PHIC,PHIB,ASMIN,
    ASMAX,CLRMN,FCM,EC,EMS,EU
=36.0 36.0 5.0 60.0 .75 .90 0 0 0 0 0 0 .003

INPUT TYPE OF REINFORCEMENT - RMODE
=?

RMODE = 1 FOR EQUALLY SPACED BARS
        2 FOR UNEQUALLY SPACED BARS
        3 FOR RANDOMLY SPACED BARS
=1

REINFORCEMENT DATA - NB,SIZBAR,CLR,0,0,CLR1,0,0,0,0,0,CLR3,0,0,0
=?
NB - NUMBER OF BARS IN SECTION
SIZBAR - SIZE OF BARS IN SECTION
CLR - CLEAR COVER TO MAIN REINFORCEMENT (IN)
       IF SAME FOR ALL ROWS
      IF COVER IS NOT SAME, INPUT ZERO
CLR1 - CLEAR COVER FOR ROW 1 (IN)
CLR3 - CLEAR COVER FOR ROW 3 (IN)
=23 8 2.0 0 0 0 0 0 0 0 0 0 0 0

INPUT TYPE OF LOAD MODE DATA - LMODE
=?

LMODE = 0 IF NO LOADINGS ARE GIVEN
        1 ONLY AXIAL LOADS ARE GIVEN
        2 AXIAL LOADS GIVEN AS GROUPS OF LOADS
        3 AXIAL LOADS AND UNIAXIAL OR BIAXIAL BENDING
=0 1 0

INPUT LOAD MODE DATA - NLC,BENDX,BENDY
=0 1 0

RUN INDICATOR - IA
=0

INPUT NAME OF OUTPUT FILE.  HIT A CARRIAGE
RETURN IF OUTPUT IS TO BE WRITTEN TO TERMINAL

=
```

STRENGTH DESIGN OF R/F.
CONCRETE COMPRESSION MEMBER -PCA-

EXAMPLE

INVESTIGATION OF
ROUND COMPRESSION MEMBERS

CONSTANTS - FC= 4.250 EC= 4074. ES= 29000. STRAIN= 0.0030

S= 36.00 T= 36.00 F'C= 5.000 FY= 60.000 PHIC= 0.750 PHIB= 0.900

WITH 23 NO. 8 BARS. AST = 18.17 SQ.IN. = 1.79 PCT. COVER = 2.000 IN.

INTERACTION CONTROL POINTS REQUESTED

	PZ	PB	MB	MZ
X-AXIS	4004.2	1351.5	1486.7	1105.5

LIMITING AXIAL LOADS - UP(MAX)= 3404.

** END OF RUNS **